Novelty vs temporal contiguity in learned taste aversions*

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Rats were administered apomorphine intraperitoneally following serial ingestion of saccharin and anise solutions. The animals had been previously familiarized with one of the solutions. An aversion to the novel stimuli developed independently of the flavor of the novel solution or of the order of presentation prior to apomorphine injection. Novelty was shown to be a more potent cue than was temporal contiguity in this particular conditioning of discriminated taste aversion. It was concluded that the long delays between CS and UCS presentation that have been found possible in the conditioned taste-aversion paradigm must be due to central processes and not to lingering aftertaste. Also, previously reported salience of certain tastes may be in part due to their novelty.

When an animal is made sick contingent upon ingestion of a distinctively flavored solution, he will tend to avoid drinking that solution upon subsequent exposures to it (Garcia & Koelling, 1967; Smith & Birkle, 1966). Typically, a taste aversion is established by following the presentation of a distinctively flavored solution (CS) by either an injection of a noxious drug, such as apomorphine, or an exposure to x-irradiation.

Many investigators have reported that specific taste aversions can be effectively conditioned using interstimulus intervals of up to several hours in length (Garcia, Ervin, & Koelling, 1966; McLaurin, 1964). It is noteworthy that taste is the only modality in which long-interval conditioning has been successful (Garcia & Koelling, 1967), and it is also the only modality in which a component of the CS may linger for some time following its nominal termination (Rozin, 1969). The mechanism which mediates long-interval taste aversion conditioning is unclear. The CS could be stored centrally throughout the CS-UCS interval or could be retained peripherally in the form of an "aftertaste." The aftertaste explanation has been recently attacked. Rozin (1969) found that an aversion could be established to one of two concentrations of the same

solution, and Nachman (1970) found that an aversion could be established to solutions of different temperatures.

Another approach to the problem would be to mask the aftertaste with the flavor of another solution before administration of the apomorphine. If the original solution is still avoided, then an aftertaste explanation is untenable. Previous work has shown that if the Ss are first familiarized with the solution that is later to be paired with the illness, the aversion to that solution is attenuated (Farley, McLaurin, Scarborough, & Rawlings, 1964; McLaurin, Farley, & Scarborough, 1963). This suggests a method by which one aftertaste may be replaced with another without establishing an aversion to the solution which produces the masking aftertaste. An aversion should not develop for the

solution producing the masking aftertaste if that solution has been already made familiar to S. An aversion for the novel solution would indicate that central factors were responsible in mediating a long-interval taste aversion, since any lingering peripheral traces would be components of the familiarized solution.

Revusky & Bedarf (1967) conducted a study utilizing this general paradigm. The animals were familiarized with sucrose, milk, or grape juice. On the conditioning day, illness was induced in the animals by x-irradiation following the presentation of the familiarized solution and a novel one. The animals tended to avoid the novel solution when subsequently given a two-bottle choice between it and the familiarized solution. The order of presentation of the two solutions before the radiation treatment had no effect on the strength of the aversion, thus suggesting that the aftertaste explanation is incorrect.

In order to test the generality of their results, it was decided to try to replicate their study, using different parameters while still retaining the basic "novelty aversion" paradigm. Apomorphine was used as the UCS rather than x-irradiation. Also, some care was taken to choose two highly flavored solutions which the Ss would prefer equally.

SUBJECTS

Forty male Sprague Dawley derived rats, weighing 250-325 g, were housed individually in 25 x 18 x 18 cm wire mesh cages with continuous access to Purina food pellets. All animals were

Fig. 1. Means of total amount (milliliters) of novel (crosshatched) and familiar (blank) solutions consumed on Day 5 for Ss familiarized with saccharin (SAC) or anise (AN), and presented with the familiar solution first (F/N) or the novel solution first (N/F) preceding apomorphine or saline injections.

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placed on a 24-h water-deprivation schedule at the start of the experiment. The only fluids available to them during the experiment were the test solutions, which were presented at the same time each day in the drinking cages.

APPARATUS

The drinking cages were similar to the home cages, but differed in that a drinking tube could be attached to the front in either a center position or at a position approximately 5 cm to the right or left of center. In addition, an 8-cm-diam cup containing food pellets was fixed to the center of the floor at the back of each cage. The drinking tubes were calibrated in milliliters and had a capacity of 100 ml. The two distinctively flavored solutions that were used for the novel and familiar stimuli were a .15% saccharin sodium solution and an anise-flavored solution containing .08% anise extract (Sauer's anise extract in 70% alcohol). A pilot study had shown that rats could discriminate between these two solutions, but that they did not show a marked preference for either one.

PROCEDURE AND EXPERIMENTAL DESIGN

The experiment was conducted in a 2 by 2 by 2 factorial design. Each of the eight groups contained five Ss. The treatments were varied according to: (1) the solution with which the animals were familiarized, (2) the order of presentation of novel and familiar CSs on the training day, and (3) the presence or absence of induced illness. The experimental paradigm consisted of three phases. On Days 1-3, the familiarization phase, all Ss were first weighed and then placed into one of the drinking cages where they were allowed 20 min access to a drinking tube in the center position and containing one of the solutions (the "familiarized" solution). One half of the Ss were familiarized with saccharin and half with anise. At the end of the drinking period, each S was returned to his home cage and the amount of the fluid consumed was recorded.

The conditioning phase took place during two separate sessions on Day 4. The first session occurred at the same time of day as each of the familiarization trials. The Ss were weighed and then placed in the drinking cages, where each of the solutions was presented serially in the center position for 2 min. One half of the Ss received the familiarized solution, followed by the novel solution. This order was reversed for the other half. The amount drunk of each solution was recorded. One half of the animals were then immediately given an injection of apomorphine (15 mg/kg, IP). The other half received

an equivalent-by-volume dose of isotonic saline. Following injection, all Ss were returned to their home cages. The identical conditioning procedure was repeated 6 h later.

The test phase took place on Day 5. The Ss were again weighed and placed into the drinking cages onto which two drinking tubes had been placed, one containing the familiar solution and the other containing the novel solution. At the end of 30 min the Ss were removed and the amount drunk of each solution was recorded. A "novelty index" (NI) was computed from this data for each S. $NI = (\# \text{ cc novel fluid}) / (\text{total} \# \text{ cc fluid})$.

RESULTS

Inspection of the NI scores indicated that the normality of the distribution was questionable, so the arcsine transformation (Winer, 1962) was employed. A 2 by 2 by 2 factorial analysis of the transformed scores indicated that the animals which received the injection of apomorphine during the conditioning phase showed the expected aversion to the novel CS on Day 5 ($F = 44.10$, $df = 1/32$, $p < .01$). There was no effect of order of presentation ($F = 1.35$, $df = 1/32$, $p \approx .25$). A reliable difference was found between the NI scores of the Ss familiarized with saccharin and those familiarized with anise ($F = 6.16$, $df = 1/32$, $p < .05$). A slight interaction between familiarization flavor and order of presentation was found ($F = 3.90$, $df = 1/32$, $p < .06$). No other interaction effects were significant. (An analysis of the total amount of novel solution consumed by each S on Day 5 yielded similar effects.) Figure 1 shows that although the Ss given apomorphine consumed less total solution on Day 5 than did the saline Ss, this generalized suppression was of much smaller magnitude than the specific suppression for the novel solution by the apomorphine Ss.

DISCUSSION

An aversion to the novel stimulus was demonstrated to develop independently of the flavor of the solution or of the order presentation of the stimuli preceding the administration of the apomorphine. Although the paradigm is a simple conditioned discrimination, it is difficult for current theories of conditioning to account for the association of the apomorphine-induced illness (UCS) with the novel solution rather than with the solution immediately preceding the UCS.

Although it would be more parsimonious to account for long-interval learning by an aftertaste rather than a central mediation, the data strongly suggest that this is not the case. It would be predicted from

the aftertaste mechanism that the solution given last would become associated with the UCS and would therefore be avoided on Day 5. A strong aversion to the novel solution was established even when the novel solution was separated from the UCS by the ingestion of the familiar solution.

Perhaps taste aversion may be considered to be a different type of learning. Other differences have also been found. Garcia & Koelling (1967) have reported that only an internal stimulus, such as illness induced by apomorphine, x-irradiation, or lithium chloride, was successful in conditioning a taste aversion. Footshock, which is effective in more traditional aversion paradigms, was not successful. Conversely, it is difficult to establish an aversion to external cues using internal UCS (Garcia, Ervin, & Koelling, 1966; Rozin, 1969). Taste aversion conditioning involves interoceptive cues, while other aversion paradigms involve exteroceptive cues. An interoceptive CS must be paired with an interoceptive UCS, or the animal will fail to learn the association. This is also true for an exteroceptive CS and UCS.

A recent article by Kalat & Rozin (1970) has demonstrated the importance of "salience" in taste aversion conditioning. When illness followed the serial presentation of two novel solutions, an aversion was developed for the more salient solution, independent of order of presentation. While Kalat and Rozin demonstrated that salience was independent of initial preference, it was not shown that novelty and "salience" were independent phenomena. It is quite possible that the more salient solutions were, in fact, solutions with a more novel taste. That is, the more salient solutions could have differed more in taste from the daily food regimen on which the rats had been "familiarized."

An alternative explanation concerning how the UCS becomes associated with the novel solution was indicated by the observation that the saline-injected animals showed a tendency toward neophilia on Day 5. Although each solution was presented for the same amount of time on Day 4, a greater amount of the novel solution would be consumed if the animals showed neophilia on this day also. It might then be argued that the UCS becomes paired with the novel solution simply because relatively more of it has been consumed. However, the Ss drank the same amount of each solution on Day 4 ($t = 1.4$, $v = 78$, $p \approx .15$).

It appears, then, that it is the

novelty of the stimulus which is the effective cue. This viewpoint is supported in the literature by McLaurin, Farley, & Scarborough (1963). They found that rats which had previously been familiarized with saccharin and then given a conditioning trial did not later develop as strong an aversion to saccharin as did animals which had not received the familiarization trials. In the present paradigm, the novel solution becomes the effective CS because the alternate solution has become familiar to S.

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